IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

N06/4/PHYSI/SP2/ENG/TZ0/XX+

88066505

PHYSICS
STANDARD LEVEL
PAPER 2

Friday 3 November 2006 (afternoon)

1 hour 15 minutes

Candidate session number

0	0							

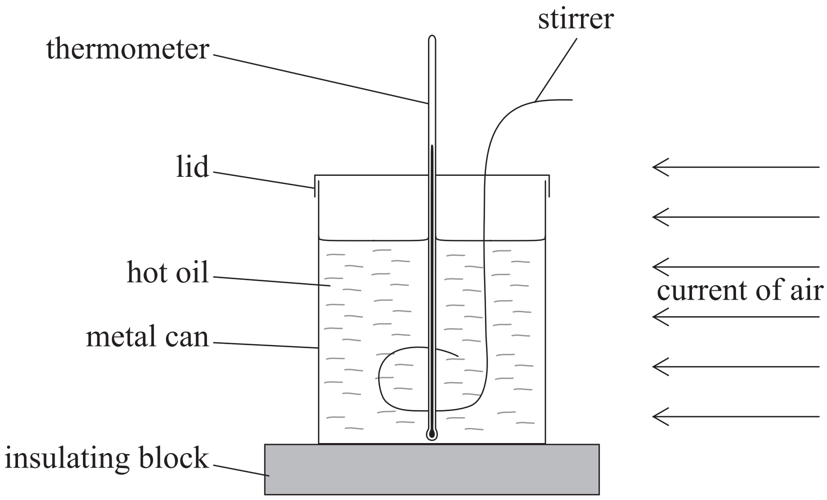
INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet.

SECTION A

*Answer **all** the questions in the spaces provided.*

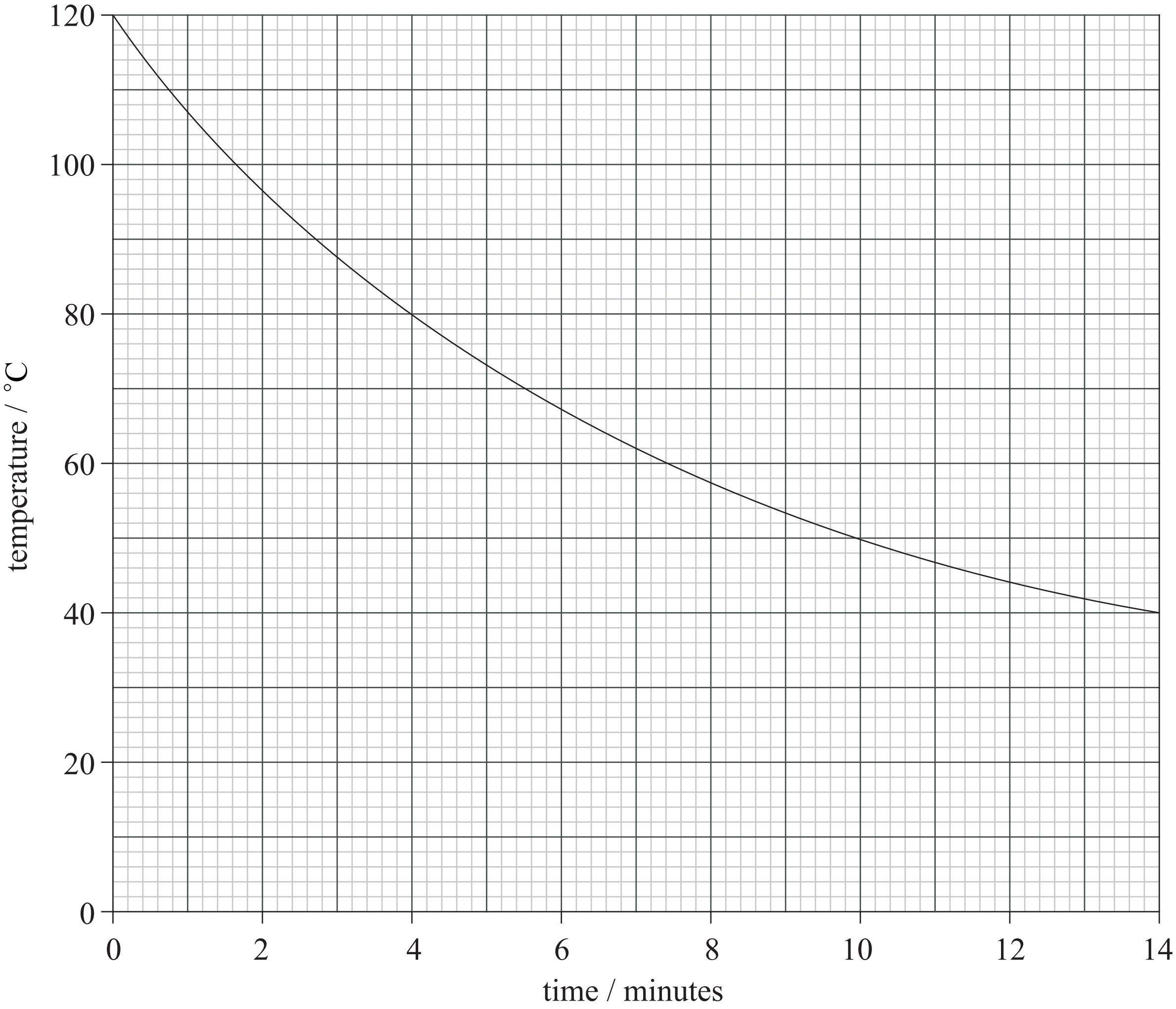
A1. A hot object may be cooled by blowing air past it. This cooling process is known as forced convection. In order to investigate forced convection, hot oil was placed in a metal can. The can was placed on an insulating block and air was blown past the can, as shown below.



(This question continues on the following page)

(Question A1 continued)

The hot oil was stirred continuously and its temperature was taken every minute as it cooled. The graph below shows the variation with time of the temperature of the cooling oil.



It is thought that the rate R of decrease of temperature depends on the temperature difference between the oil and its surroundings (the excess temperature θ_E). The temperature of the surroundings was 26 °C.

(a) On the graph above,

(i) draw a straight-line parallel to the time axis to represent the temperature of the surroundings. *[1]*

(ii) by drawing a suitable tangent, calculate the rate of decrease of temperature, in °C s^{-1}, for an excess temperature of 50 Celsius degrees (°C). *[4]*

. . . .

. . . .

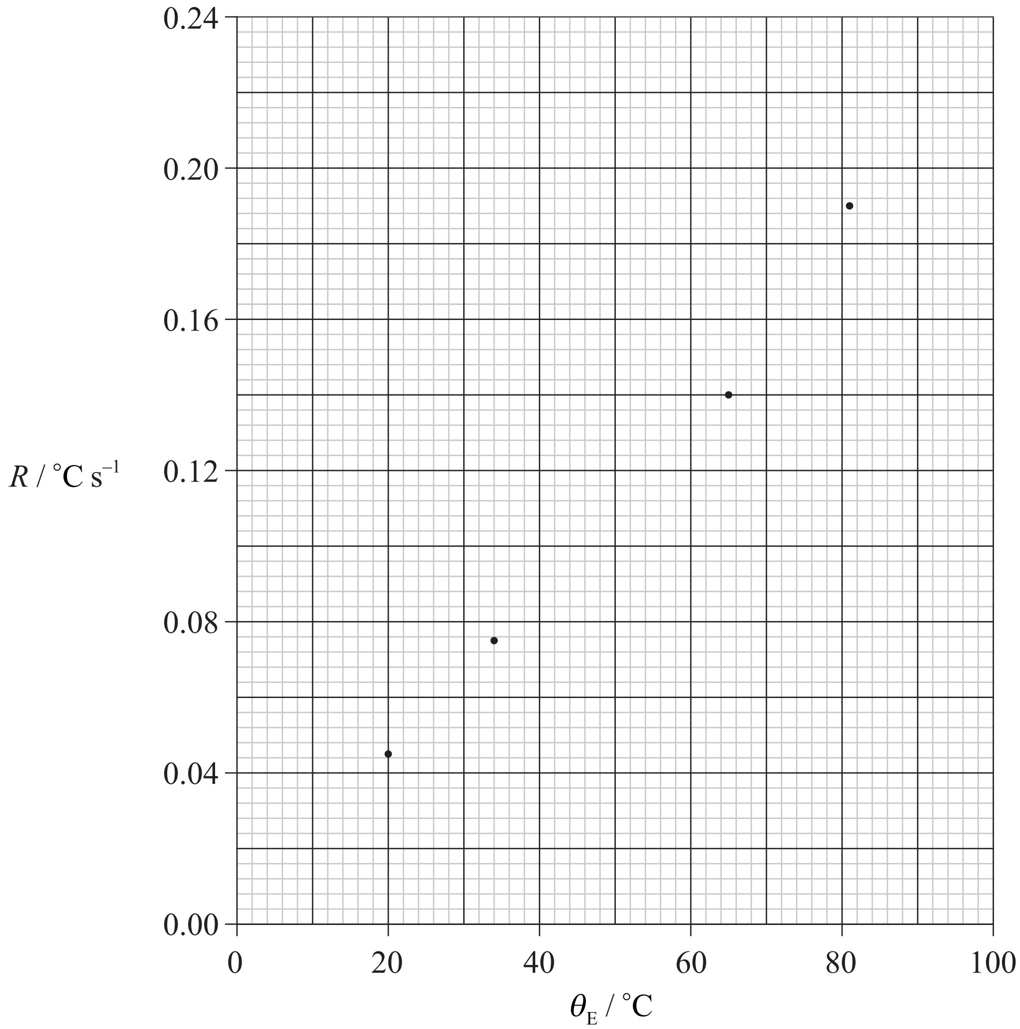
. . . .

. . . .

(This question continues on the following page)

(Question A1 continued)

(b) In order to investigate the variation with R of θ_E, a graph of R against θ_E is plotted. The graph below shows four plotted data points. Uncertainties in the points are not included.



(i) Using your answer to (a)(ii), plot the data point corresponding to $\theta_E = 50$ °C. *[1]*

(ii) The uncertainty in the measurement of R at each excess temperature is ±10%. On the graph, draw error bars to represent the uncertainties in R at excess temperatures of 20 °C and 81 °C. *[2]*

(This question continues on the following page)

(Question A1 continued)

(c) Explain why the graph in (b) supports the conclusion that the excess temperature θ_E is related to the rate of cooling R by the expression

$$R = k\theta_E ,$$

where k is a constant. *[3]*

. . . .

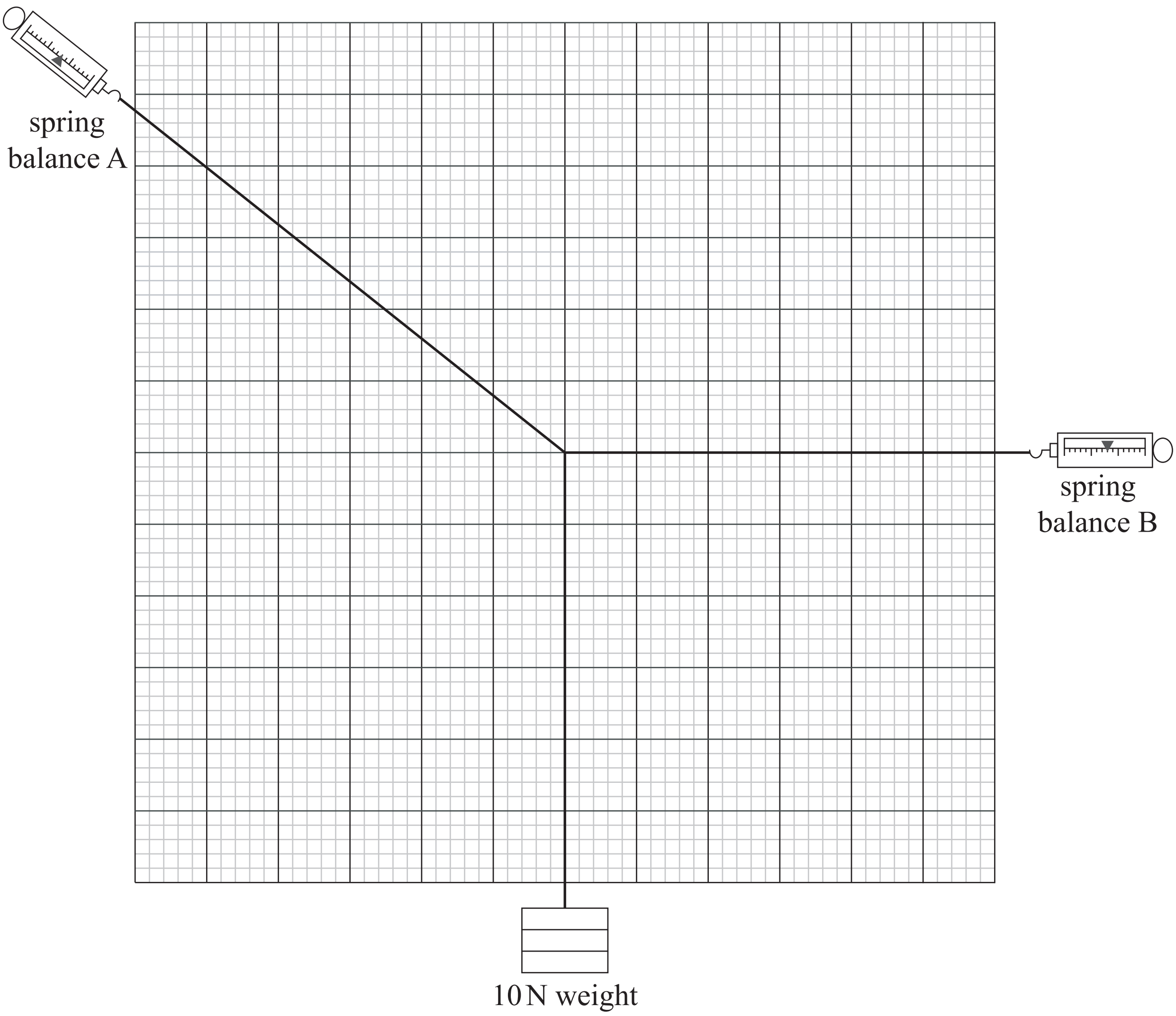
. . . .

. . . .

. . . .

A2. This question is about vectors.

A student sets up the apparatus shown below to investigate forces.



The weight of 10.0 N is suspended from spring balance A by means of a light string. Spring balance B is also attached to the string. The spring balance B is pulled horizontally as shown.

(a) Using the grid on the diagram, draw a scale diagram to determine the readings on each of the spring balances. *[4]*

Reading on spring balance A: . . . .

Reading on spring balance B: . . . .

(b) Suggest why it is **not** possible for the whole length of the string joining spring balances A and B to be horizontal with the weight still suspended. *[1]*

. . . .

. . . .

A3. This question is about temperature and internal energy.

Two solid copper spheres, having different radii, undergo the same temperature change. A student states that the change in internal energy of the two objects would be the same. Briefly discuss this statement. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

A4. This question is about nuclear binding energy.

The table below gives the mass defect per nucleon of deuterium $\left({}^{2}_{1}\text{H}\right)$ and helium-4 $\left({}^{4}_{2}\text{He}\right)$.

	Mass defect per nucleon / *u*
${}^{2}_{1}\text{H}$	0.00120
${}^{4}_{2}\text{He}$	0.00760

(a) Explain the term *mass defect*. *[2]*

. . . .

. . . .

. . . .

(b) Calculate the energy, in joule, that is released when two deuterium nuclei fuse to form a helium-4 nucleus. *[4]*

. . . .

. . . .

. . . .

. . . .

Blank page

SECTION B

This section consists of three questions: B1, B2 and B3. Answer ***one*** *question.*

B1. This question is in **two** parts. **Part 1** is about linear motion and **Part 2** is about collisions.

Part 1 Linear motion

(a) Define the term *acceleration.* *[2]*

. . . .

. . . .

(b) An object has an initial speed u and an acceleration a. After time t, its speed is v and it has moved through a distance s.

The motion of the object may be summarized by the equations

$$v = u + at,$$

$$s = \tfrac{1}{2}(v + u)t.$$

(i) State the assumption made in these equations about the acceleration a. *[1]*

. . . .

(ii) Derive, using these equations, an expression for v in terms of u, s and a. *[2]*

. . . .

. . . .

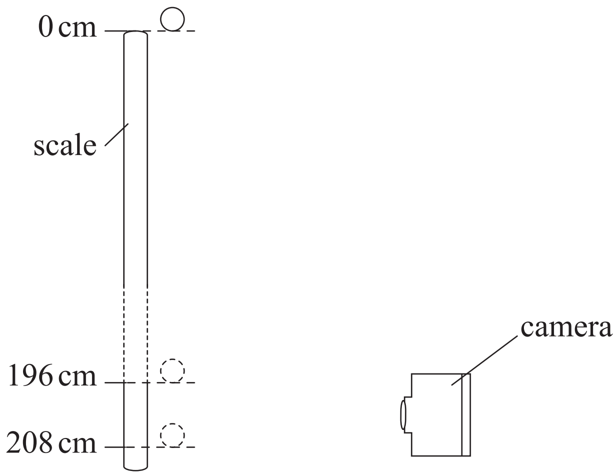
. . . .

. . . .

(This question continues on the following page)

(Question B1, part 1 continued)

(c) The shutter speed of a camera is the time that the film is exposed to light. In order to determine the shutter speed of a camera, a metal ball is held at rest at the zero mark of a vertical scale, as shown below. The ball is released. The shutter of a camera is opened as the ball falls.



The photograph of the ball shows that the shutter opened as the ball reached the 196 cm mark on the scale and closed as it reached the 208 cm mark. Air resistance is negligible and the acceleration of free fall is $9.81\ \text{m s}^{-2}$.

(i) Calculate the time for the ball to fall from rest to the 196 cm mark. *[2]*

. . . .

. . . .

. . . .

(ii) Determine the time for which the shutter was open. That is, the time for the ball to fall from the 196 cm mark to the 208 cm mark. *[2]*

. . . .

. . . .

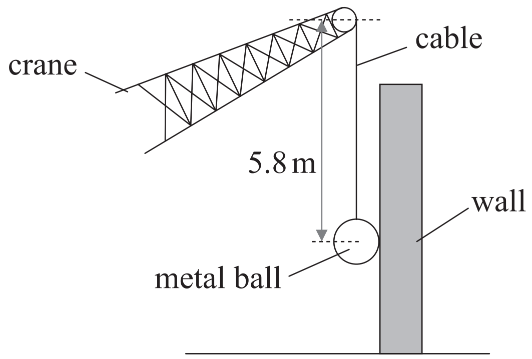
. . . .

(This question continues on the following page)

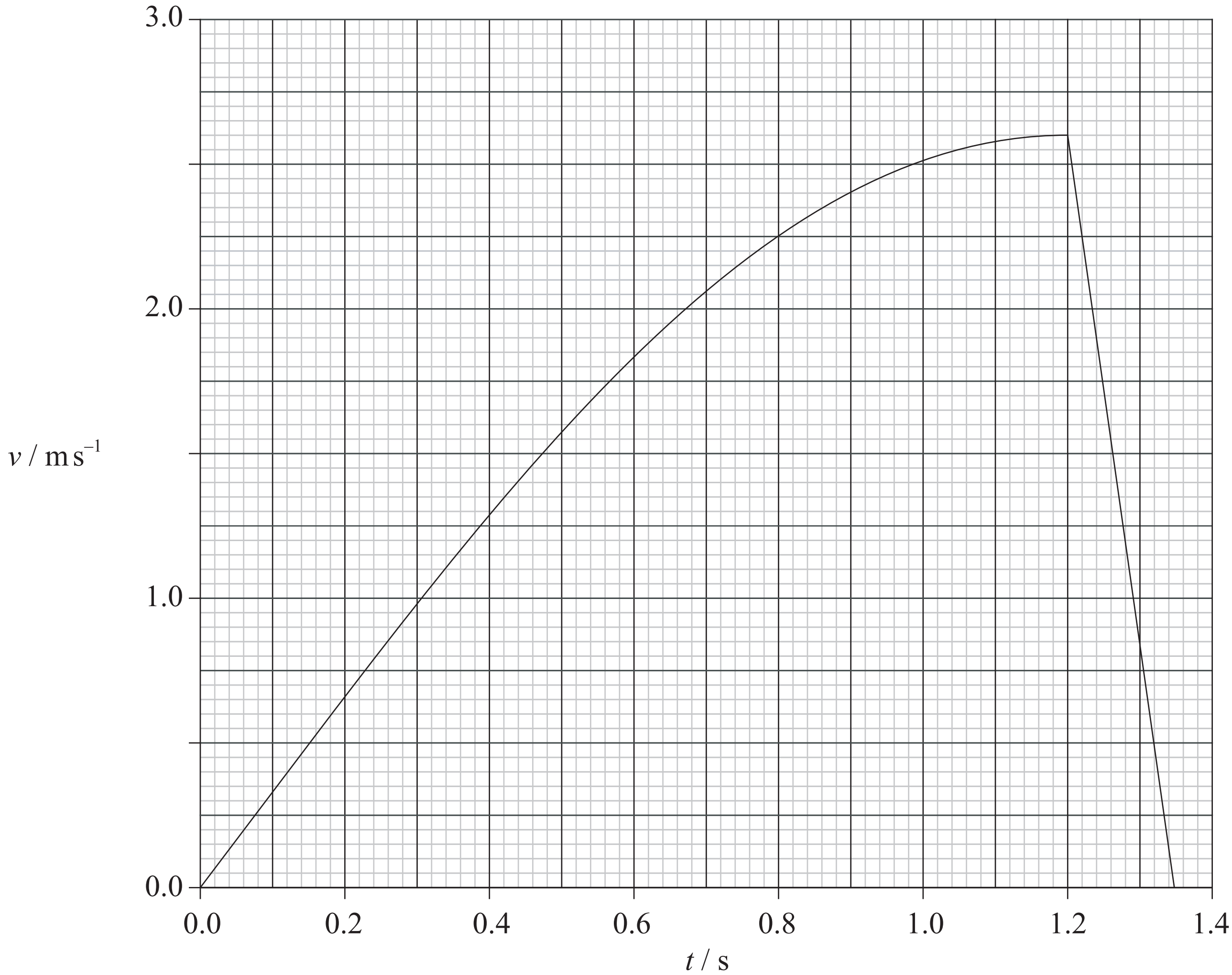
(Question B1 continued)

Part 2 Collisions

A large metal ball is hung from a crane by means of a cable of length 5.8 m as shown below.



In order to knock down a wall, the metal ball of mass 350 kg is pulled away from the wall and then released. The crane does not move. The graph below shows the variation with time t of the speed v of the ball after release.



(This question continues on the following page)

(Question B1, part 2 continued)

The ball makes contact with the wall when the cable from the crane is vertical.

(a) For the ball just before it hits the wall,

(i) state why the tension in the cable is not equal to the weight of the ball. *[1]*

. . . .

. . . .

(ii) by reference to the graph, estimate the tension in the cable. The acceleration of free fall is $9.8\,\mathrm{m\,s^{-2}}$. *[3]*

. . . .

. . . .

. . . .

. . . .

(b) Use the graph to determine the distance moved by the ball after coming into contact with the wall. *[2]*

. . . .

. . . .

. . . .

. . . .

(c) Calculate the total change in momentum of the ball during the collision of the ball with the wall. *[2]*

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B1, part 2 continued)

(d) (i) State the law of conservation of momentum. *[2]*

. . . .

. . . .

. . . .

(ii) The metal ball has lost momentum. Discuss whether the law applies to this situation. *[2]*

. . . .

. . . .

. . . .

. . . .

(e) During the impact of the ball with the wall, 12 % of the total kinetic energy of the ball is converted into thermal energy in the ball. The metal of the ball has specific heat capacity 450 $\text{J kg}^{-1}\,\text{K}^{-1}$. Determine the average rise in temperature of the ball as a result of colliding with the wall. *[4]*

. . . .

. . . .

. . . .

. . . .

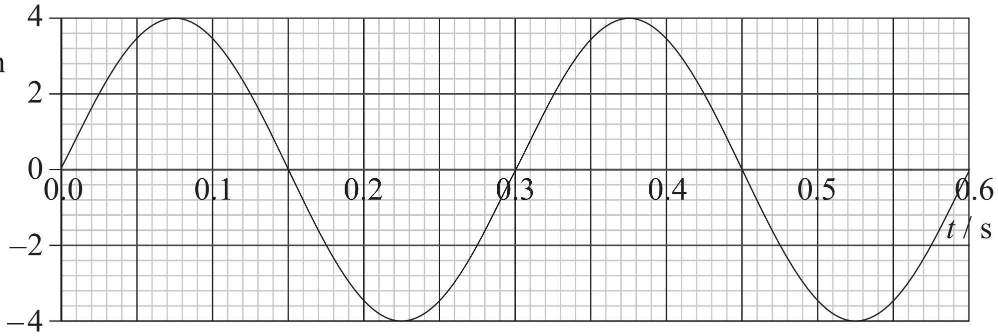
B2. This question is in **two** parts. **Part 1** is about wave phenomena and **Part 2** is about gases.

Part 1 Wave phenomena

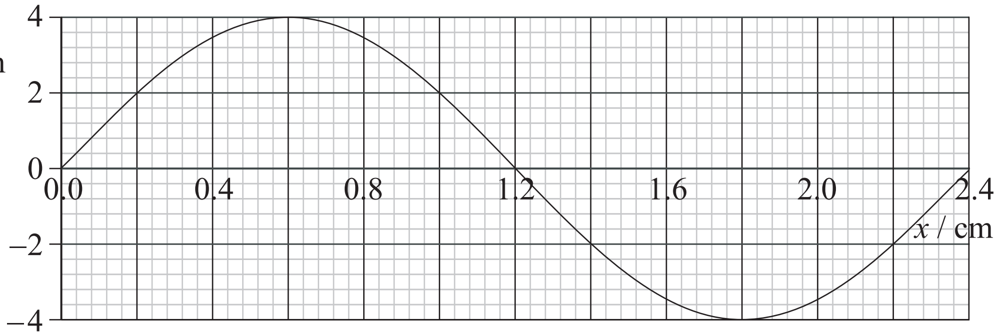
Travelling waves

(a) Graph 1 below shows the variation with time t of the displacement d of a travelling (progressive) wave. Graph 2 shows the variation with distance x along the same wave of its displacement d.

Graph 1



Graph 2



(i) State what is meant by a *travelling* wave. *[1]*

. . . .

. . . .

(ii) Use the graphs to determine the amplitude, wavelength, frequency and speed of the wave.

Amplitude: . . . . *[1]*

Wavelength: . . . . *[1]*

Frequency: . . . . *[1]*

. . . .

Speed: . . . . *[1]*

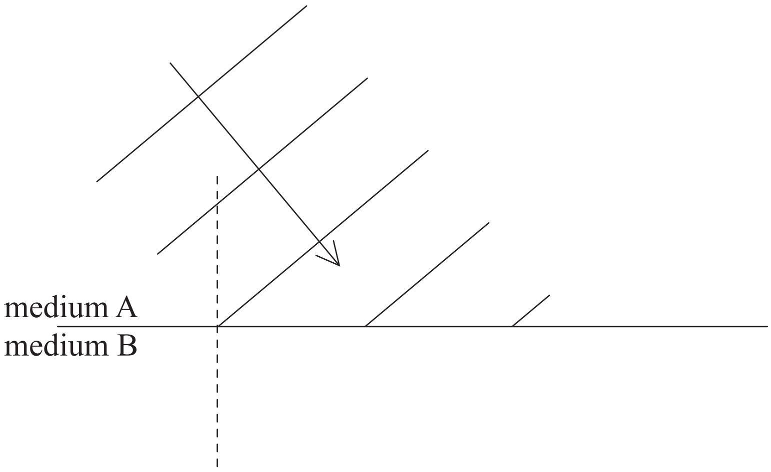
. . . .

(This question continues on the following page)

(Question B2, part 1 continued)

Refraction of waves

(b) The diagram below shows plane wavefronts incident on a boundary between two media A and B.



The ratio $\dfrac{\text{refractive index of medium B}}{\text{refractive index of medium A}}$ is 1.4.

The angle between an incident wavefront and the normal to the boundary is 50°.

(i) Calculate the angle between a refracted wavefront and the normal to the boundary. *[3]*

. . . .

. . . .

. . . .

. . . .

(ii) On the diagram above, construct **three** wavefronts to show the refraction of the wave at the boundary. *[3]*

(This question continues on the following page)

(Question B2 continued)

Part 2 Gases

A car tyre has a constant volume of $1.17 \times 10^{4}\,\text{cm}^{3}$. The pressure of the air in the tyre is $2.70 \times 10^{5}\,\text{Pa}$ at a temperature of 17.0 °C. Air may be assumed to be an ideal gas.

(a) Calculate the amount, in mol, of air in the tyre. *[3]*

. . . .

. . . .

. . . .

(b) An air-pump delivers 8.00×10^{-3} mol of air into the tyre on each stroke of the pump. Calculate the number of complete strokes of the pump required to increase the air pressure in the tyre to 3.10×10^{5} Pa at 17.0 °C. *[4]*

. . . .

. . . .

. . . .

. . . .

(c) On each stroke of the pump, the average force applied to the pump is 280 N and the force moves through a distance of 9.0 cm.

(i) Calculate the total work done on the pump in order to inflate the tyre. *[2]*

. . . .

. . . .

. . . .

(ii) During the increase in air pressure in the tyre, the additional energy stored in the compressed air is 225 J. Calculate the efficiency of the pumping process. *[2]*

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B2, part 2 continued)

(d) Air is, in fact, not an ideal gas. As a result, the equation of state

$$pV = nRT$$

is not strictly correct for air.

The equation of state can be modified to allow for non-ideal behaviour. Suggest, with a reason, whether the term V in the gas equation should be increased, decreased or remain unchanged to allow for the finite size of air molecules. *[3]*

. . . .

. . . .

. . . .

. . . .

B3. This question is in **two** parts. **Part 1** is about electricity. **Part 2** is about radioactivity.

Part 1 Electricity

Static electricity

(a) By reference to the movement of charge in a metal and in plastic, explain the electrical properties of conductors and insulators. *[3]*

. . . .

. . . .

. . . .

. . . .

(b) A gold-leaf electroscope is positively charged.

(i) Outline why there is no electric field inside the metal cap of the electroscope. *[2]*

. . . .

. . . .

. . . .

(ii) A student touches the metal cap of the electroscope. Describe the movement of charge that occurs. *[2]*

. . . .

. . . .

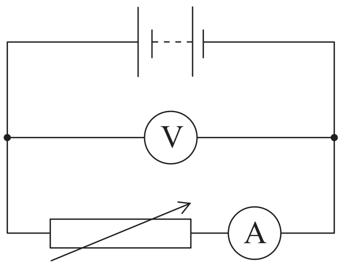
. . . .

(This question continues on the following page)

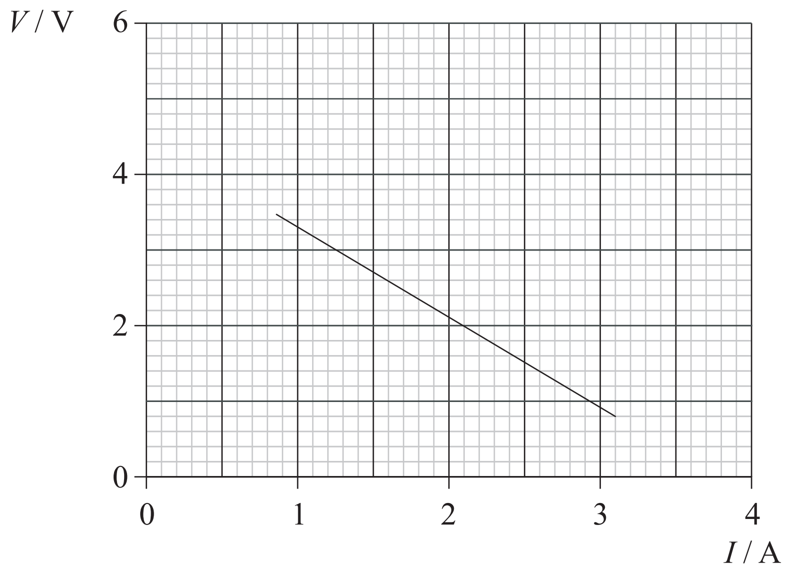
(Question B3, part 1 continued)

Current electricity

(c) In order to investigate the variation of the current I in a variable resistor with the potential difference V across it, a student set up the following circuit.



The variation of the current I with V is shown below.



Use the graph to deduce that, for the battery,

(i) its e.m.f. is 4.5 V. *[2]*

. . . .

. . . .

. . . .

(ii) its internal resistance is 1.2 Ω. *[2]*

. . . .

. . . .

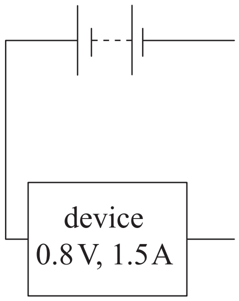
. . . .

(This question continues on the following page)

(Question B3, part 1 continued)

(d) The battery in (c) is to be used as the power source for an electrical device. The device is rated as 0.8 V, 1.5 A.

Complete the circuit below to show how the battery may be connected so that the device operates normally. Calculate the value of any other component you may use. *[4]*



. . . .

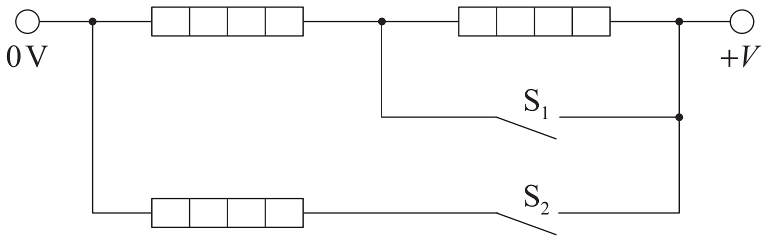
. . . .

. . . .

(This question continues on the following page)

(Question B3, part 1 continued)

(e) An electric heater contains a number of similar heating elements, connected as shown to a supply of V volts. The switches S_1 and S_2 are shown "open".



Each heating element dissipates power P when connected to a supply of V volts. The resistance of each element may be considered to be constant.

Complete the table below to give the total power dissipated, in terms of P, for the switches in the positions indicated. *[3]*

Switch S_1	**Switch S_2**	**Total power**
closed	closed	
closed	open	
open	open	

(This question continues on the following page)

(Question B3 continued)

Part 2 Radioactivity

One isotope of potassium is potassium-42 $\left({}^{42}_{19}\text{K}\right)$. Nuclei of this isotope undergo radioactive decay with a half-life of 12.5 hours to form nuclei of calcium.

(a) State what is meant by the term *isotopes*. *[2]*

. . . .

. . . .

. . . .

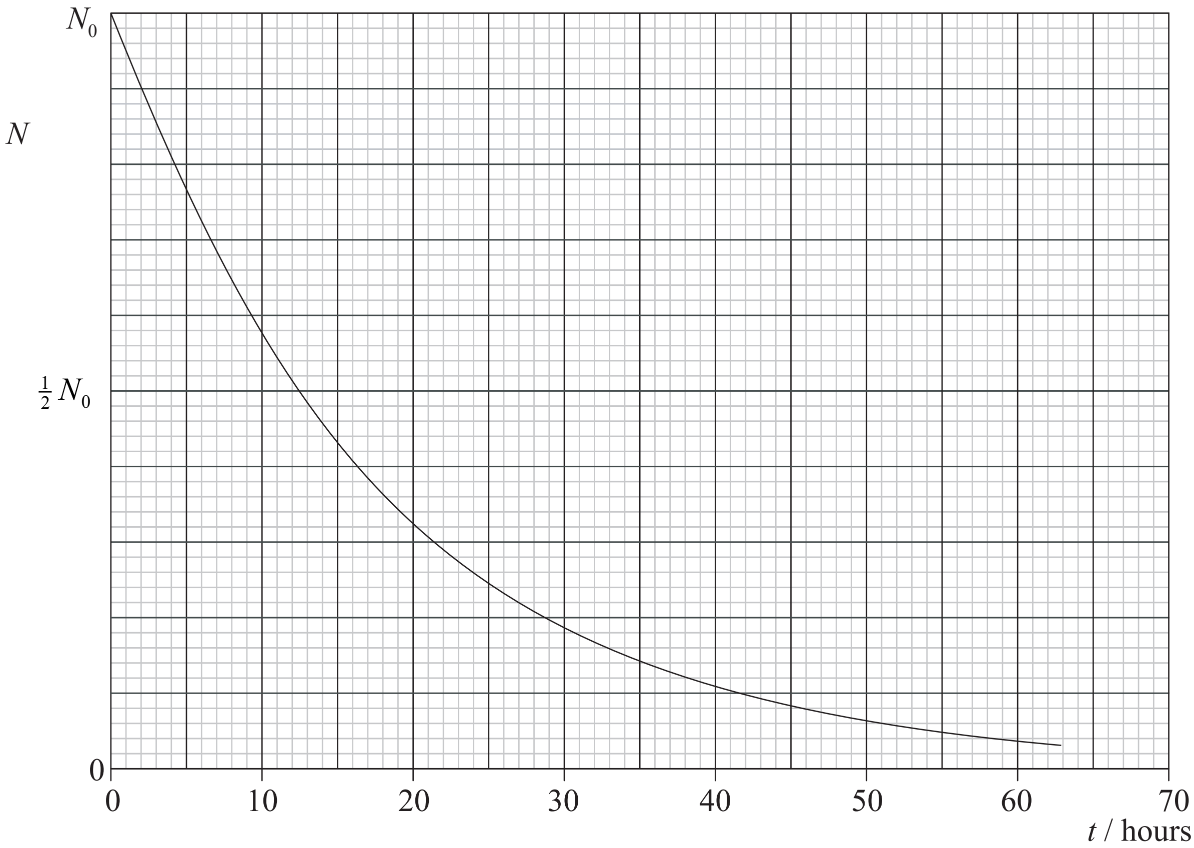
(b) Complete the nuclear reaction equation for this decay process. *[2]*

$$ {}^{42}_{19}\text{K} \rightarrow {}_{20}\text{Ca} + $$

(This question continues on the following page)

(Question B3, part 2 continued)

(c) The graph below shows the variation with time of the number N of potassium-42 nuclei in a particular sample.



The isotope of calcium formed in this decay is stable.

On the graph above, draw a line to show the variation with time t of the number of calcium nuclei in the sample. *[1]*

(d) Use the graph in (c), or otherwise, to determine the time at which the ratio

$$\frac{\text{number of calcium nuclei in sample}}{\text{number of potassium-42 nuclei in sample}}$$

is equal to 7.0. *[2]*

. . . .

. . . .

. . . .